ANSWERS: Acids and Bases

1) Hydrochloric acid + calcium carbonate → calcium chloride + carbon dioxide + water.

$2HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2O$

2) Beaker 1 = water

The green colour of the universal indicator indicates that this solution has a pH of 7 and therefore is neutral. The fact that both litmus papers stay the same colour also indicates that the liquid is neutral and has a pH of seven, and therefore Beaker 1 must be water.

Beaker 2 = vinegar

The orange colour of the universal indicator indicates that the solution is acidic and has a pH of 4–5. Because the blue litmus turns red, this also indicates that the solution is acidic, and therefore Beaker 2 must be vinegar (ethanoic acid)

Beaker 3 = baking soda

The blue colour of the universal indicator indicates that the liquid is basic and has a pH of 9–10. Because the red litmus turns blue, this also indicates that the liquid is basic, and therefore Beaker 3 must be basic, as baking soda (sodium hydrogen carbonate) is basic.

Beaker with a pH of one is more acidic. In both solutions there are an excess of hydrogen ions compared to hydroxide ions, but in the solution with a lower pH the number of hydrogen ions is much more in excess compared to hydroxide ions; whereas when the pH is 6 the hydrogen ions are still in excess but not by as much.

3) Equations

Sulfuric acid + sodium hydroxide → sodium sulfate + water

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Explanations

The solution would be purple to start with, as the pH would be 13–14. The pH would be high, as there is a high number of OH^- ions present. At this stage OH^- ions are in excess when compared to H^+ ions.

As H_2SO_4 is added, the solution would go blue. At this stage the pH would be 8–12 and OH^- ions are still in excess of H^+ ions, but not by as much as when the solution was purple. When the solution becomes green, the amount of H^+ ions added (from the H_2SO_4) cancel out the OH^- ions from the sodium hydroxide and form water in a neutralisation reaction. At this stage the pH would be 7.

As more H_2SO_4 is added, the solution then turns yellow, then orange, and then red. When the solution is yellow or orange, the pH is 3–6 as there are now more H^+ ions present than OH^- ions. When it becomes red, the pH is 1–2, as there are now many more H^+ ions present than OH^- ions

4 a) Sulfuric acid + potassium hydroxide → potassium 2ulphate + water

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

b) As the KOH is added, the H_2SO_4 is being neutralised until water is formed, then after that the solution becomes more basic.

When no KOH has been added, the solution is red and has a pH of 1–2 and there is an excess of H^+ ions. As the solution becomes orange-yellow, the pH becomes 4–6. There is still an excess of H^+ ions but not as big an excess as when the pH was lower. When 10 ml has been added and the solution is green, the pH is 7, which is neutral. At this point, the number of H^+ and OH^- ions is equal and they cancel each other out to form water. After 15 mL has been added and the solution is blue, the pH is 9–12 and there is now an excess of OH^- ions. When 20 mL have been added and the solution is purple, the pH is 13–14 and there is now a greater excess of OH^- ions than when the solution was blue.

Litmus paper is useful to tell us if a solution is acidic, basic or neutral. (When blue litmus turns red and red litmus stays red, this tells us the solution is acidic. When both blue and red litmus papers stay the same, this tells us the solution is neutral. When red turns blue, this tells the solution is basic.) Universal Indicator (UI) however tells us more information and tells us how acidic, basic a solution is or if it is neutral. Litmus is limited as it only tells us if it is acid, basic, or neutral whereas UI tells us how acidic or basic it is.
You don't have to keep dipping / adding UI like you do litmus paper.
(UI may be answered for solution or paper.)

5) a) The purpose of Experiment 1 is to make the neutral salt, calcium chloride.
b) UI is used to check the pH of the solution. Calcium hydroxide is added so that it reacts with HCl to form calcium chloride. It is added until the solution is green so that the solution formed is neutral. The contents are put into an evaporating dish so that the water can evaporate to leave the salt calcium chloride. It is left for a few days to ensure that all the water has evaporated as this process takes time.

c) *Experiment 2*
hydrochloric acid + sodium carbonate → sodium chloride + water + carbon dioxide
$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$
d) Fizzing would be observed.
The fizzing observed is due to carbon dioxide gas being released, and therefore because the carbon dioxide gas is leaving the beaker, there is less mass remaining in the beaker and therefore the balance measures less weight.

6a) Equations
Sulfuric acid + sodium hydroxide → sodium sulfate + water
$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

b) c) d) Explanations

Beaker one (acid)

The solution would be red to start with as the pH would be 1–2. The ions present in solution would be H^+. The pH would be low as there is a high number of H^+ ions present.

As NaOH is added the solution would go orange, then yellow, then green. When the solution is orange and yellow the pH is still less than 7 as there are still more H^+ than OH^- ions. When the solution becomes green the amount of OH^- ions added (from the NaOH) cancel out the H^+ ions from the sulfuric acid and form water in a neutralisation reaction. At this stage the pH would be 7.

As more NaOH is added the solution then becomes blue and then purple. When the solution is blue the pH is 8 -11 as there are now more OH^- ions present than H^+ ions. When it becomes purple the pH is 13 – 14 as there are now many more OH^- ions present than H^+ ions.

Beaker two (water)

The solution is green initially as water contains equal numbers of H^+ and OH^- ions and is pH 7. As NaOH is added, the solution would become blue (pH 8 - 11) and then purple (pH 13 – 14). Because the water was neutral to start with, as more OH^- ions are added, the solution becomes more basic as the OH^- ions are immediately in excess.

7) How to make it

Mix the two solutions together, then take the resulting solution and put it in an evaporating dish. It could be heated using a Bunsen burner or left somewhere warm for a few days. The water would evaporate off leaving behind the neutral salt sodium nitrate.

The solution will be neutral when red and blue litmus papers both stay the same colour. When blue paper changes to red the solution is acidic. When red paper changes to blue the solution is basic.

Word Equation

nitric acid + sodium carbonate → sodium nitrate + water + carbon dioxide.

Balanced Equation

$2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$

8) Explanations

When the solution is red, the pH is 1–2. The colour is due to a high concentration of H^+ ions.

When the solution is green, the solution is neutral pH 7 and the hydroxide ions have reacted with the hydrogen ions, forming water.

When the solution is purple, the pH is 12–13 and there is a high concentration of hydroxide ions.

Word equation

Nitric acid + sodium hydroxide → sodium nitrate + water

Balanced equation

$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

9) Type of reaction

Acid-Base reaction or neutralisation.

Word Equation

hydrochloric acid + magnesium oxide → magnesium chloride + water.

Balanced Equation

$2HCl + MgO \rightarrow MgCl_2 + H_2O$

How to make it

Add magnesium oxide to hydrochloric acid in a beaker. Heat slightly and pour this into an evaporating dish and leave somewhere warm (e.g. window sill) for a few days or heat over Bunsen to speed up the reaction, so that the water can evaporate, leaving magnesium chloride salt. Safe lab procedure would include dealing appropriately with chemicals such as HCl or the wearing of safety glasses

10) a) i) Description of colour changes:

- red / pink to start with blue / purple / violet at end.

ii) Explanation of colour changes:

At the beginning the red indicated a low pH due to excess H^+ ions in the solution.

As the NaOH was added, a yellow / green colour indicates a pH of around 7, due to the OH^- ions combining with the H^+ ions to form a neutral solution.

As more NaOH is added the blue / purple indicated a pH of 11 plus, due to excess OH^- ions in the solution.

b) Identification of reaction type:

Acid-base (or acid-carbonate) neutralisation (the carbonate ions react with the H^+ ions of the acidic solution and neutralise the solution).

Description of observations:

Bubbling in the solution / fizzing / effervescence / frothing / foaming Ca_2CO_3 disappears.

Linking observations to products:

The products are CO_2, H_2O and a salt. The CO_2 gas causes the bubbles / fizzing / etc.

Writing a word equation:

Nitric acid + sodium carbonate $\rightarrow$ sodium nitrate + water + carbon dioxide

Writing a symbol equation:

$2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$

11) Explains that the fizzing is a resultof carbon dioxide being formed.

$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$

Explains that the fizzing (effervescence) is a result of carbon dioxide being formed.

Explains that the Na_2SO_4 is soluble, so final solution is colourless.

12) $[H^+] = [OH^-]$ / $H^+ + OH^- \rightarrow H_2O$

At the beginning the solution is red / orange due to the H_2SO_4 and U.I. At neutralisation the solution turns yellow-green / green.

Sodium hydroxide + sulfuric acid → sodium sulfate + water

$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

Neutralisation is when a salt and water are produced because the amount of acid = the amount of base. The NaOH increases the pH towards 7 by cancelling out the acid.

Neutralisation is when the products of the reaction are pH 7 and (as the amount of H_30^+ = the amount of OH^-) the amount of acid equals the amount of base (when pH = 7 = $[H_30^+][OH^-]$).

At the beginning the solution is red due to the H_2SO_4. At neutralisation it is yellow-green / green due to the Na_2SO_4 and H_2O (or no H_2SO_4) present.

Explains clearly how they would ascertain neutralisation using an appropriate indicator, eg. Add a few drops of Universal Indicator solution. Monitor colour changes as reaction proceeds: red in acid → yellow-green / green when neutral.

13) $ZnO + H_2SO_4 \rightarrow H_2O + ZnSO_4$

ZnO_2 changed to ZnO, as ZnO has a one to one ratio because Zn forms Zn^{2+} / ion and oxygen a O^{2-} / ion.

H_2 was removed from the equation as hydrogen gas is not a product of an acid + base (metal oxide) reaction.

Balanced equations show the same amount / number of atoms on each side so '2' is removed from $2H_2O$ as there are 2 H on the left.

14) a)

Estimated pH	Colour when tested with Universal indicator
	(i) red
(ii) 8 – 12	
	(iii) yellow/orange
(iv) 7	

b) Sodium hydrogen carbonate + hydrochloric acid → carbon dioxide + sodium chloride + water

$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

At pH 6.5 the pool water is too acidic so sodium hydrogen carbonate is added to raise the pH back to the ideal region of pH 7 to 7.6 as it is a base and it neutralises the acid.

15) a) Water – red and blue

NaOH – blue and blue

HCl – red and red.

b) Water – 7

NaOH between 9 and 14.

HCl between 0 and 3.

16) a) Sulfuric acid chosen.

b) Because it has the sulfate ion required. Copper chloride would be formed with hydrochloric acid.

Copper oxide + sulfuric acid →copper sulfate + water

c) Solution bubbles. When an acid reacts with a carbonate, carbon dioxide gas is produced which will be observed as bubbling.

d) $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

17)a) red

green / blue

blue / purple

b) i) Bubbles form

ii) $K_2CO_3 + 2HCl \rightarrow 2KCl + CO_2 + H_2O$

c) At the beginning – red due to HCl (acidic)

- at neutralisation – yellow / green due to NaCl and H_2O (or no HCl) present beyond neutral point – blue with NaCl and NaOH present (basic).

18) a) i) magnesium sulfate sulfuric acid

ii) iii) sulfuric acid + magnesium hydroxide → magnesium sulfate + water

b) Products of the reaction are neutral as the amount of H_3O^+ = amount of OH^-

19) a) i) yellow, green, blue (all required in order)

ii) Red

iii) NaOH increases the pH by neutralising or cancelling out the acid.

Low pH means more acid (*hydrogen ions*) :

As the NaOH base added, acid is neutralised / canceled out reaching pH 7 / neutral : more NaOH increases further / pH = 11+.

Correct use of 'neutralises' required. Reference to H+ ions not reqd.

20) The one that fizzes with acid is the carbonate **OR** The one that doesn't fizz is the oxide.

Do not accept any mention of the oxide producing a gas as an Achievement statement, nor the use of any other equipment or tests.

$Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$

21)a) i) red blue

ii) red blue

b) i) oven cleaner

ii) lemon juice

iii) Toothpaste is basic/alkaline OR neutralises the acid.

22) i) carbon dioxide/ CO_2

ii) sulfuric acid + sodium hydrogen carbonate → water + carbon dioxide + sodium sulfate

iii) $H_2SO_4 + 2NaHCO_3 \rightarrow 2H_2O + 2CO_2 + Na_2SO_4$

Carbonates and hydrogen carbonates are bases so this is a neutralisation reaction where the products include a salt and water.

The pH will be around 7 because [H3O+]=[OH-].

A full explanation including products, final pH and balance of ions